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Analytical Approach to the Identification of Hazardous Road Locations: A Review of the Literature*

by

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ABSTRACT

A broader review of the literature on the identification of hazardous road locations using cross-sectional, textual and comparative analysis teaches us different lessons: limits of the methods have to be clearly identified in view of broader applications; a holistic approach in terms of assessing the importance of the different elements involved and in terms of dealing with a dynamic system has to be considered; the optimization of the process prioritizes actions to correct accident risks locations; such actions are linked by financial and human ressources, availability of data, cost benefit evaluation and social and political orientations which in turn, raises the whole question of the price for life.

Key words: Hazardous road location, meta-analysis, black spots, road safety.

RÉSUMÉ

Les méthodes d'identification des lieux à risque élevé d'accident sont le sujet de nombreuses études dans la littérature internationale depuis les deux dernières décennies.

Nous présentons ici une synthèse critique des principales méthodes utilisées: méthodes quantitatives, probabilistes, behavioristes, analyse des conflits, investigation en profondeur et méthode des échantillons.

La discussion va au-delà des schèmes et souligne la complexité d'oeuvrer dans un système dynamique multifactoriel. Nous constatons que la priorisation des actions pour corriger les points noirs est limitée par les ressources financières et humaines, la disponibilité et la fiabilité des données est entravée par la rationalisation des coûts versus les bénéfices, l'orientation sociale, politique et médiatique du moment, ce qui nous mène à nous poser la question: combien vaut une vie?

Mots-clés: Méthodes d'identification des lieux dangereux, points noirs, sécurité routière.

ANALYTICAL APPROACH TO THE IDENTIFICATION OF HAZARDOUS ROAD LOCATIONS: A REVIEW OF THE LITERATURE

INTRODUCTION

Traffic accidents happen in certain locations and for the past twenty years, engineers, researchers and others who are dedicated to reduce those accidents have been trying to understand, systematize and correct hazardous road locations. However, the problem continues and is as critical as it was before. Because of the large amount of information published on the subject and the variability of methodology and criteria, as well as certain discrepancies between the results of different papers, we found appropriate to restate the question by means of a comprehensive study based on an extensive review of the literature. Specific objectives were to establish a tool which enables comparisons between different aspects of the studies, to analyse trends and recent orientations, and to stimulate reflexion on the subject.

METHODS

We carried out research of existing information by using "in-office" references, an extensive data-base-information research, T.R.I.S. (Transportation Research Information Service), and by exchanging information with people and agencies involved with this issue. From among all the references reviewed, we

have kept thirty papers (Bernier & Ellefsen, 1989; Biggs, 1983; Brownfield , 1984; Brown, 1972; Burr & Brogan, 1976; Charest & Beaudoin, 1987; Corben & Miller, 1985; Ferrandez, Fleury & Malaterre, 1979; Fleiszer & Chipman, 1989; Foyster, 1984; Haddon, 1980; Hauer & Persaud, 1983; Institute of transportation engineers, 1986; Joly, 1985; Kamel & Cartshore, 1982; Lapierre, 1988; Leslie, 1977; Mahalel, Hakkert & Prashker, 1982; Maher & Mountain, 1988; Messier, 1989; McGuigan, 1981; Moorehead, 1982; OCDE, 1976; OCDE, 1986; Persaud, 1987; Petersen, 1973; Quesnel, 1987; Sergerie & Brown, 1989; Silcock & Smith, 1984; Zegeer, 1982) which are representative of the various trends in dealing with this problem. Those papers have been the object of an in-depth investigation. The method used for synthesizing the different information was inspired by meta-analysis. Meta-analysis is a method for synthesizing information by using a systematic integration and statistic analysis of various research results. A cross-sectional review of the papers (méthode croisée) has been implemented. It consists in three steps: Step I establishes a comprehensive grid of the main points we wish to look for; Step 2 consists of filling the grid by scrutinizing the information in each paper (one paper - one resumé); Step 3 consists of reporting section-by-section the different points on a meta-plan. The grid included the following items: objectives of the study; terminology and definitions used; population or scale of the study; data and their availability; methods and techniques including criteria used for identifying risk locations; problems and biases; utilization and range of the study. For analyzing the definitions and terminology, we had to implement a method of

textual analysis which is similar to that used in literature, i.e. an analysis of the substance and the form including frequencies of term use, meanings and context. All the results reported on the meta-plan are the object of a comparative analysis. Then a discussion and illustration of different methodological and practical issues is presented.

RESULTS

Objectives

The main goal of the studies was to reduce traffic accidents, in terms of numbers or in terms of gravity. Various sub-objectives were pointed out. The objective of 30% of the studies was to elaborate a methodology for identifying high-risk accident locations, useful for a specific study area (3 out of 4) or applicable to other comparative locations (1 out of 4). The objective of 20% of the other studies was to evaluate different methodologies. The objective of 20% of the studies was to make a listing of hazardous risk locations in a specific study area and to rank them. Other objectives correspond to a special interest and each of them contributed to 10% of the variation. These special objectives are to identify a specific hazardous environment feature (ex. bridge piers); to identify a specific type of accident (ex: night accident in urban areas); and to identify a specific environmental condition (ex: impact of wet pavement).

Definitions: terms and concepts

The terminology and definitions used by the authors varied greatly. In English, hazardous spot, blackspot, hazardous road location, hazardous section, high accident site, bad accident site, high risk area were terms used; in French, site dangereux, lieux à risque, point noir, point dangereux du réseau routier, section dangereuse du réseau routier, zone à risque, zone dangereuse, danger routier, lieu ou endroit à forte concentration d'accidents. We originally thought that definitions given by the authors (these were not present in every paper) could help us in understanding the differences between these terms. Unfortunately, similar terms had different meaning from one author to another and different definitions were often linked to similar terminology.

The most usual definition is "High Accident Frequency" and "High Mortality Frequency" (30% of the papers); "High Injury Frequency" or "High Injury Rate" and "High Severity Rate" contribute to 25% of the frequency of terms used, followed by "High Accident Rate" (20%). "Potential High Risk Location" contributes to 10% of the frequency. Other definitions match the objectives of the studies and were quite specific, referring to a special population (i.e. pedestrians) or to a methodology (as Potential Accident Reduction or Comparative Accident Rate). Definitions are not exclusive to each study. The general theme is reflected in the following definition:

> "A hazardous location (problem location, dangerous location, abnormal location) is one that presents a risk to the driver in terms of high probability of accident occurrence or high accident severity. This risk may or may not be reflected in past accident records. Many locations, i.e., slick pavements, narrow bridges, or with rigid fixed objects near the roadway, may have a high accident potential without necessarily having a history of high accident occurrence".
> Institute of Transportation Engineers, 1986.

Mainly, three concepts underly these definitions: The first refers to the study scale (spot versus area); the second refers to actual or potential accident locations; the third is connected to the orientation of the research and the people it was addressed to.

Population, scale and length of the study

Most of the papers do not clearly identify the population studied or at risk. Only, references to states, countries and cities are indicated; however the population under study is specified more precisely when the study covers an administrative area (i.e. Community Health Department).

For 60% of the studies, we observed a strong dichotomy between rural and urban locations, but 40% do not refer to that distinction. The scale of the studies are spots or intersections 25% of the time, road segment 50% of the time, and areas 25% of the time. Many studies use different scales together. Curiously, information about scale was missing at a rate of 70% for the studies published before 1986 and 12% for the studies published after that year.

The length of data collection is mainly three years (44%); 28% of the studies collected datas during one or two years and 28% during four or five years.

Data

The sources of data were mainly public (nine out of ten studies), such as accident reports filled out by the police or roadway inventories and traffic reports developed by transportation agencies. In some of the studies, police accident report data are complemented by hospital or coroners reports, but that situation is quite exceptional. Questionnaires sent to the population for identifying high risk locations and surveys carried out on other participants (emergency staff or policeman on duty) are often used for collecting data. However conflicts studies were collecting specific observation datas.

Methods and techniques

Eighty-five per cent of the studies were retrospective using a posteriori material. Three main groups of methods can be identified: quantitative and statistical methods, observational methods and specific sampling methods.

Quantitative and statistical methods

Quantitative and statistical methods are the most commonly used (72%). They include a) various frequency and rate methods with or without specific reference to the gravity of the injuries, and b) methods which include references to probabilistic models. Quantitative methods are used to determine

where, when and how trafric accidents most frequently occur. The **frequency method** is used to identify locations on the basis of the number of accidents. The **rate method** combines the accident frequency with exposure in term of volume of traffic or other parameters.

Statistical methods consist of the application of a probabilistic model (for instance based on the assumption that accidents follow a Poisson distribution) to determine the locations where the level of risk to the road user is significantly greater than can be normally expected.

Observational methods

Observational methods (20%) include a) traffic conflict methods which try to assess by observation the frequency and type of "near-accident" situations in specific location, b) behavioral methods which observe driver's actions and errors in a specific controlled environment, c) in-depth investigations of accidents or on-the-spot investigation (a short-time after the event).

The conflict method is a prospective method based on the observation of incidents or situations close to the accident involving one or more vehicles which cause a disruption in the normal traffic flow or change in the orderly pattern of driving behaviour in specific locations. **The behavioral method** observes and records driver's actions and errors made at different locations and then compares them to accident frequency at those locations. **In-depth investigation**

method is used to record elements of the road user, vehicle, road and traffic characteristics which has led to the accident and to analyze them and their combination. It usually involves a multidisciplinary team and on-spot observation.

Specific sampling methods

Specific sampling methods (8%) include methods a) which aggregate specific environmental and road feature characteristics and b) which aggregate different types of accidents. The sampling method is used to aggregate available data from accidents which are thinly spread throughout the road system but have some similarity either concerning environmental and road feature characteristics or accident type.

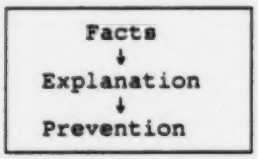
The majority of the authors (65%) use one specific method and 30% of them use two methods; a few use more than two. These are not counting papers whose objectives were to compare methodologies.

The choice of criteria for identifying hazardous road locations is directly limited to a) the objective of the study and b) the availability of the data. A broad range of weightings are involved (i.e. traffic flow, gravity, population density) and conditions (i.e. numbers of accidents by road segment; "high" differences between observed and expected accident numbers; a certain number of injured people linked with right turn on red). The "cut" between high risk locations

and the others seems to depend on an "in-house" criteria: it could be .5% of high accident locations during the past one or two or three years; a road segment with 3 or more accident; five accidents per year and 12 accidents per 3 years for main road, and so on.

DISCUSSION

All studies are based on the following process:



Beginning with facts (accidents or to-be accidents) we try to explain them in order to prevent further accidents and improve road safety. But many difficulties are inherent in all steps. It is mainly due to the essence of accidents: they are rare events which happen often, they are multifactorial events and they happen in a non-static system. However, despite these limitations, reducing traffic accidents is an important goal as imperfect as it is.

What is the price for life?

We found that a specific objective was present in just about all the papers we reviewed: the **optimization of the process** of reducing hazardous road location.

This involves a complex prioritizing exercise linked to financial and human resources, availability of data, cost-benefit evaluation and social and political orientations. Where do we cut in accident ranking? What type of accidents do we have to consider? Frequency versus gravity? Frequency and gravity? Specific accident type versus cost of engineering improvement?

Basis of the facts: the data

Facts are based on data. What are their reliability? Are they representative of the problem? Are they accurate? How long do we have to collect them? How much do we need? How useful are extensive characteristics? What scale and region do we have to consider in a study? All those questions have to be looked at - if not answered. We found that accent on the limits of the data is not clearly specified enough in about every paper reviewed and thus prevents comparisons between the results.

Spot, section or area?

What spatial scale do we have to consider? The answer depends more on the purpose of the study and the availability and accuracy of the data than on any other methodological issue. If the purpose is related to engineering matters, scale is more oriented to inches than to miles; if the purpose is preventive community safety in an urban high risk space, spots, sections or small areas would be appropriate, mainly because we are aware of the close interaction between causative factors.

The reliability of accident locations based on police reports

The main source of accident data used for retrospective studies is police reports. How do these work? In urban areas, if the accident took place at an intersection, the police report usually gives the name of the two streets. Taking into account the fact that many times the exact spot of the impact is a result of many different factors, it could be of interest to look at all nearby intersections. If the accident took place on a street section, the police report indicates the civic address of the house in front of the accident location. In that case further investigation could be useful, as a high number of accidents at the same address previously reported by different police officers, or if the address is remarkable in some way, reinforce the level of confidence in reporting the accident spot. An alternative could be to examine the street segment. In rural areas, different methods of reporting are used. In Quebec, we use the Mercator system with a square grid of 1 km by 1 km as reference. An in-depth study (Morin, Pouliot & Vandermissen, 1989) indicated that 50% of the data were located erroneously. However another study (Shinar, Treat & McDonald, 1983) in Indiana indicated high reliability on the localization of road accidents as registered in police reports. An extensive study on the extent and implications of incomplete accident reporting has been performed recently (Hauer & Hakkert, 1987). The authors state that "Fatalities are known to an accuracy of 5% but 20% of injuries requiring hospitalization and perhaps 50% of all injuries are not in official statistics". Former studies indicated that many injured children (40%) are driven directly to an emergency hospital without any

police accident record on file (Joly, Foggin & Pless, 1989; Pless, Verreault, Arsenault & Frappier, 1987). The problem of underreporting compounds that of erroneous location. Those examples illustrate the necessity to be aware of data reliability. It also indicates the necessity of implementing a national (or provincial) system of accident registration.

A dynamic system

The main problem encountered is created by the fact that we are dealing with a dynamic system. First, different things change in the environment during the period used for collecting data: traffic volume, traffic direction, pedestrian traffic connected to the opening of a commercial area for instance. In addition road characteristics evolve over time. Then, the essence of the event: an analysis of data during three years for a specific area, using the same source, the same methodology, and the same criteria indicates that hazardous locations move around (Joly, Bergeron & Symon, 1990). A study in the United States showed a correlation between accidents in successive years of 0.62 to 0.62 at certain locations without any outwardly noticeable changes occurring in traffic flow or the traffic network (Pugh & Halprin, 1974). Some researchers (Persaud, 1987; Abbess, Jarrett & Wright, 1981; Boyle & Wright, 1984) have been interested by this and have named it "migration of blackspots"; different explanations have been given but the controversy is still going on (Maher & Mountain, 1988; McGuigan, 1981). Is it a random phenomenon? Does any improvement in spot "A" push accidents to the periphery? Or is it simply

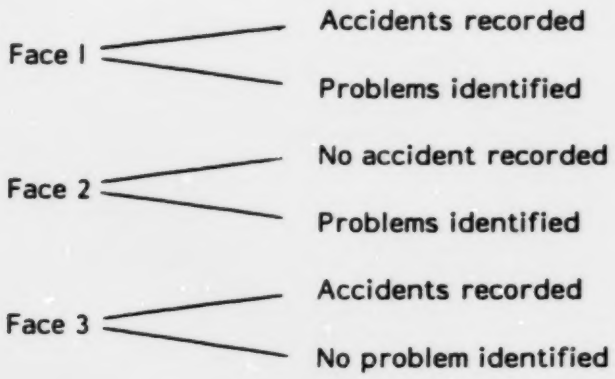
"regression to the mean"? Regression to the mean is a statistical concept which, in the current context, states that predictions should fall closer to the mean of all spots rather than the observed rate at any one spot. If at time 1, spot "A" shows a high number of accidents, at time 2 that number will diminish - and regress to the mean - and vice-versa for another spot B. Accidents move spatially, but are not eradicated. However, accident rates have been decreasing slightly in some countries.

The interrelationship of factors

The problem of traffic accidents is multi-factorial: characteristics of the vehicle, the driver and the environment are interrelated. For explaining the causes of the accident - which is a priority for establishing in what field improvements have to be made - we need to assess the importance of the different elements involved and their inter-relationships and reactions. That is one of the most difficult tasks.

Experts assess than the road user contributes to between 75% to 95% of accidents. Following this, the road and traffic environment contributes to 20% to 30% of accidents and the smallest contributor is the vehicle with 10% to 15%. The high contribution of the driver could be explained by his actions, his errors but also by his incapacity to adapt to the pressures of the driving environment; inadequate compliance with the rules of safe driving is another opportunity for decreasing highway accidents (OCDE, 1976).

The three faces of hazardous location



Hazardous locations show three different faces: Face I corresponds to a correct positive identification; Face 2 corresponds to a false negative identification and Face 3 corresponds to a false positive identification. Pragmatically we assume than this situation occurs often. This indicates the necessity of improving the availability and accuracy of data on a long term basis. It also underlines the fact that identifying hazardous road locations must not be a separate process but must be integrated into the overall process of identifying and evaluating accident measures.

CONCLUSION

This study indicates that different techniques and methods are available and applicable in most places if care is taken. It indicates also the inadequacy in term of reducing traffic accidents - of most methods. Some thought regarding

alternative actions would be very interesting: studies on positive guidance for the driver and studies involving risk perception analysis of environmental elements would be of great interest. We have to remember that road accidents are still one of the major causes of mortality and morbidity in the industrialized world.

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GOLD COAST, AUSTRALIA,

MAY 20-23, 1990

IDENTIFYING HAZARDOUS ROAD LOCATIONS: METHODOLOGICAL ISSUES

Matériel de présentation

Identifying Hazardous Road Locations

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Problematic

Traffic accidents happen in certain locations

- *Large amount of information published*
- *Variability of methodology and criteria*
- *Discrepancies between the results*

Objectives

To restate the question by means of a comprehensive study

- *To establish a tool for comparisons*
- *To analyse trends*
- *To stimulate reflexion*

Results

Objectives

The main goal of the studies was to reduce traffic accidents

30% - to evaluate a method for identifying high risk locations

20% - to evaluate different methodologies

20% - to list and rank hazardious locations

10% - to identify a specific risk feature

10% - to identify a specific type of accident

10% - to identify a specific environmental condition

Definitions : *great variations*

30% - High Accident Frequency
Mortality

25% - High Injury Frequency
Severity Rate

20% - High Accident Rate

10% - Potential high risk locations

5% - others

Three concepts :

- *refers to the study scale (spot/area)*
- *refers to actual or potential accident locations*
- *connected to the orientation of the research*

Data sources :

- *Mainly public sources (90%) :*
  police accident reports,
  hospital or coroner reports

- *Others (10%) :*
  by questionnaire
  by observation

Population : *not clear identification*

Scale : *dichotomy rural / urban*

25% - spots or intersections
50% - road segments
25% - areas

Before 1986 information about scale is missing for 70% of the studies

After 1986 12% is missing

Length of data collection :

3 years (44%)
1-2 years (28%)
4-5 years (28%)

Methods : *Mainly retrospective*

Quantitative and statistical methods (72%)

- *frequency methods*
- *rate methods*
- *probabilistic methods*

Observational methods (20%)

- *traffic conflict methods*
- *behavioral methods*
- *in-depth investigation methods*

Specific sampling methods (8%)

Use :

65% - use one specific method
30% - use two methods
5% - use more than two methods

Criteria *: directly limited to*

a) the objective of the study
b) the availability of the data

Conclusion

- *The optimization of the process involves a prioritizing exercice linked to financial and human resources, availability of data, cost-benefit evaluation and social and political orientation : what is the price for life ?*
- *Limits of the data (reliability, accuracy, representativity), is not clearly specified enough and this prevents comparisons*
- *We are dealing with a dynamic system which has to be considered*

Conclusion

- *We need to assess the importance of the different elements involved vehicule, driver, environment and their relationship*
- *This study indicates that different techniques and methods are available and applicable ;*
  it indicates also the inadequacy in terms of reducing traffic accidents of most methods
- **Some thoughts regarding alternative actions (positive guidance, risk perception analysis) is strongly recommended**

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WHAT CAN WE LEARN FROM THE EXPERIENCE OF RISK LOCATION IDENTIFICATION?

Matériel de présentation

What can we learn from the Experience of Risk Location Identification?

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PROBLEMATIC

Traffic accidents tend to happen in certain location

MAIN OBJECTIVE

To reduce accident

CONCEPTUAL FRAME

- *to understand the problem*
- *to systematize the information*
- *to make the correction*

METHODS

A broader review of the literature on accident risk location identification

In depth analysis of thirty studies using three complementary methods

- *A cross-sectional method using a reference grid*
- *A textual analysis method*
- *A comparative analysis*

Description of main methods

I QUANTITATIVE AND STATISTICAL METHODS

- The Frequency Method *is used to identify location on the basis of the number of accidents*

- The Rate Method *combines accident frequency with exposure*

- The Statistical Method *is used to determine the location where the level of risk is significantly greater than normally expected*

II. OBSERVATIONAL METHODS

- The Traffic Conflict Method :
  a prospective method based on the observation of situation "close to accident"

- The Behavioral Method :
  a prospective method based on the observation of driver's actions

- The Investigation Method:
  observation are ad-posteriori and involves a multidisciplinary team

III. SAMPLING METHOD

Aggregation of data of specific characteristics

Results

Objectives

The main goal of the studies was to reduce traffic accidents

30% - to elaborate a methodology for identifying high risk locations

20% - to evaluate different methodologies

20% - to list and rank hazardous locations

10% - to identify a specific hazardous environment feature

10% - to identify a specific type of accident

10% - to identify a specific environmental condition

The Data

Data sources:

- *Mainly public sources (90%) :*
  police accident reports,
  hospital or coroner reports
- *Others (10%) :*
  by questionnaire
  by observation

Limits of the data:

- *Lack of specification*
- *The population studied or at risk was not clearly identified*
- *Area and scale were not clearly specified*

Solutions to oppose to the halo effect

- **At the individual level**

  Be precise
  Be specific
  Be aware of under-reporting

- **At the national or provincial level**

  The necessity of implementing a system of accident registration

Problems to consider

- *Traffic accidents are multi-factorial and we need to assess the importance of the different elements involved (vehicule, driver, environment) and their relationship*

- *We are dealing with a dynamic system which has to be considered:*

  Evolution of road characteristics

  "Migration" of black spots

Conclusion

- *We prone that identifying hazardous road locations must not be a separate process but must be integrated into an overall process of identifying and evaluating accident measures*

- *We have to be aware that the optimization of the process involves a complex prioritizing exercise linked to* **financial** *and* **human resources**, *availability of* **data** **cost-benefit evaluation** *and* **social** *and* **political orientation**
  What is the price for life?

- *Different techniques and methods are available and applicable, however we have to also draw conclusions about the inadequacy in terms of reducing traffic accidents of most methods*

- **Some thoughts regarding alternative action (positive guidance, risk perception analysis) is strongly recommended**

We have to remember that road accidents are still one of the **major causes** *of* **mortality** *and* **morbidity** *in the industrialized world*